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APPLICATION FOR UNITED STATES LETTERS PATENT

for

USING A VIRUS CHECKER IN ONE FILE SERVER TO CHECK FOR VIRUSES IN ANOTHER FILE SERVER

by

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BACKGROUND OF THE INVENTION

1. Limited Copyright Waiver

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2. Field of the Invention

The present invention relates generally to data processing networks, and more particularly to data storage in a data processing network. In particular, the invention relates to using a virus checker in one file server to check for viruses in another file server.

3. Description of Related Art

A computer virus is an intrusive program that infects computer files by inserting in those files copies of itself. When a file containing a virus is executed, the virus may replicate and infect other files, and cause damaging side effects.

As data networks become more open to permit a multiplicity of diverse users to share access to files, the networks are subjected to an increasing threat from viruses. The threat has been addressed by restricting the origin of files to trusted sources, and by using virus checker software to scan the files before the files are executed.

Virus checking software has been installed in a variety of locations within a data network. Users are familiar with virus checking software that runs as a background task

on personal computers and workstations. This virus checking software has the disadvantage that it may be disabled or in need of updating to recognize new viruses.

Due to the relative difficulty of maintaining virus checking software on workstations in a network, the virus checkers have been installed in proxy servers and file servers in the network. A proxy server can function as a gatekeeper or filter for files received or transmitted by a group of workstations. A proxy server having a virus checker is an effective means for virus protection for services, such as electronic mail, that are insensitive to transmission delay due to the time that the virus checker needs for scanning the files received or transmitted. The scanning time, however, is relatively long compared to the time for data access in a file server. Therefore, it is often expedient to forego virus checking when accessing a file in a file server. This approach demands that any file contained in the file server must have been scanned for possible viruses before reading from the file. The file server, for example, contains a virus checker utility that scans for viruses. When a user closes a file after any write access to the file, the file is scanned for possible viruses that may have been introduced during the user's write access, before any other user is permitted to open the file. If the virus checker in the file server detects a virus in a file, the file remains locked by the operating system of the file server until the infected file is deleted or disinfected.

There are several difficulties with incorporating a conventional virus checker program into a file server. Conventional virus checkers are written to be loaded and linked with a conventional operating system, such as UNIX or Windows NT. If the file server does not use a conventional operating system, then there will be considerable effort to port the virus checker into the operating system of the file server. In such a case,

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1   the provider of the virus checker program may not offer technical assistance or support

2   for the porting effort or maintenance of the virus checker in the environment of the

3   unconventional operating system. In any case, the supplier of the conventional virus

4   checker may demand a license or royalty payment for use of the virus checker program

5   on each file server.

6   **SUMMARY OF THE INVENTION**

7   In accordance with one aspect, the invention provides a method of operation in a

8   data processing system. The data processing system including at least one client, a first

9   file server coupled to the client for data access of the client to at least one file in the first

10   file server, and at least a second file server coupled to the first file server for data access

11   of the second file server to the file in the first file server. The second file server is

12   programmed with a virus checker program. The virus checker program is executable by

13   the second file server to perform an anti-virus scan upon file data in random access

14   memory of the second file server. The method includes the first file server responding to

15   a request for access from the client to the file in the first file server by determining that an

16   anti-virus scan of the file should be performed, and initiating the anti-virus scan of the

17   file by sending to the second file server a request for the anti-virus scan including a

18   specification of the file. Then the second file server responds to the request for the anti-

19   virus scan by invoking the virus checker program to perform an anti-virus scan of the

20   specified file by obtaining file data of the file from the first file server and storing the file

21   data of the file into the random access memory of the second file server and performing

22   the anti-virus scan upon the file data of the file in the random access memory.

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1   In accordance with another aspect, the invention provides a method of operating a

2   network file server to initiate a virus scan upon a file stored in the network file server.

3   The network file server is coupled to at least one client for access of the client to at least

4   one file in the network file server, and the network file server is coupled to a plurality of

5   secondary servers for access of the secondary servers to the file stored in the network file

6   server. The network file server includes a cached disk array and a plurality of data mover

7   computers coupled to the data network and coupled to the cached disk array for

8   responding to client requests for data access to storage in the cached disk array. Each

9   secondary server is programmed with a virus checker program executable for performing

10   an anti-virus scan upon file data in random access memory of the secondary server. The

11   method includes at least one of the data movers in the network file server responding to a

12   request for access from the client to the file in the network file server by applying a filter

13   upon a file extension of the file upon opening or closing of the file to determine that an

14   anti-virus scan of the file should be performed, and initiating the anti-virus scan of the

15   file by applying a load balancing procedure for selecting one of the secondary servers for

16   performing the anti-virus scan of the file, and sending to the selected secondary server a

17   request for the anti-virus scan including a specification of the file. Then the selected

18   secondary server responds to the request for the anti-virus scan by invoking the virus

19   checker program in the selected secondary server to perform an anti-virus scan of the

20   specified file by obtaining file data of the file from the network file server and storing the

21   file data of the file into the random access memory of the selected secondary server and

22   performing the anti-virus scan upon the file data of the file in the random access memory

23   of the selected secondary server.

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1   In accordance with yet another aspect, the invention provides a method of

2   operation in a data network including a first server and a second server. The second

3   server is coupled by the data network to the first server for access of the second server to

4   at least one file stored in the first server. The second server is programmed with an

5   operating system supporting processes executing in a user mode and processes executing

6   in a kernel mode. The operating system of the second server includes an input/output

7   manager executing in the kernel mode. The method is a way of operating the second

8   server to perform an anti-virus scan upon the file in the first server. A server for virus

9   checking executes in the second server in the user mode. The server for virus checking

10   receives from the network a request for the anti-virus scan upon the file. Then the server

11   for virus checking forwards the request to a virus checker initiator driver executing in the

12   second server in the kernel mode, and the virus checker initiator driver responds to

13   receipt of the request by sending a file access call to the input/output manager. Then the

14   input/output manager responds to the file access call by reporting the file access event to

15   a virus checker program executing in the second server in the user mode, and the virus

16   checker program responds by obtaining file data from the file in the first server and

17   storing the file data in random access memory in the second server, and performing an

18   anti-virus scan upon the file data in the random access memory in the second server.

19   In accordance with another aspect, the invention provides a method of operation

20   of a data mover in a network file server. The network file server is in a data processing

21   system that further includes at least one client coupled to the network file server by a data

22   network for access of the client to at least one file in the network file server, and a

23   plurality of NT file servers coupled to the network file server by the data network for data

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access of the NT file servers to the file in the network file server. The network file server includes a cached disk array and a plurality of data mover computers coupled to the data network and coupled to the cached disk array for responding to client requests for data access to storage in the cached disk array. Each of the NT file servers is programmed with a virus checker program that is executable by the NT file server to perform an anti-virus scan upon file data in random access memory of the NT file server. The method includes the data mover in the network file server responding to a request from the client for access to the file in the network file server by applying a filter upon a file extension of the file upon opening or closing of the file to determine that an anti-virus scan of the file should be performed, and initiating the anti-virus scan of the file by selecting a next one of the NT file servers in round-robin fashion and sending to the selected NT file server a request for the anti-virus scan including a specification of the file. Then the selected NT file server responds to the request for the anti-virus scan by invoking the virus checker program in the selected NT file server to perform an anti-virus scan of the specified file by obtaining file data of the file from the network file server and storing the file data of the file in the random access memory of the selected NT file server and performing the anti-virus scan upon the file data of the file in the random access memory of the selected NT file server.

In accordance with yet another aspect, the invention provides a data processing system. The data processing system includes at least one client, a first file server coupled to the client for access of the client to at least one file in the first file server, and at least a second file server coupled to the first file server for data access of the second file server to the file in the first file server. The second file server is programmed with a virus

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1　　checker program. The virus checker program is executable by the second file server to

2　　perform an anti-virus scan upon file data in random access memory of the second file

3　　server. The first file server is programmed to respond to a request from the client for

4　　access to the file in the first file server by determining that an anti-virus scan of the file

5　　should be performed, and initiating the anti-virus scan of the file by sending to the second

6　　file server a request for the anti-virus scan including a specification of the file. The

7　　second file server is programmed to respond to the request for the anti-virus scan by

8　　invoking the virus checker program to perform an anti-virus scan of the specified file by

9　　obtaining file data of the file from the first file server and storing the file data of the file

10　　in the random access memory of the second file server and performing the anti-virus scan

11　　upon the file data in the random access memory.

12　　　　In accordance with another aspect, the invention provides a network file server.

13　　The network file server is adapted for coupling to at least one client for access of the

14　　client to at least one file in the network file server. The network file server is also

15　　adapted for coupling to a plurality of secondary servers for access of the secondary

16　　servers to the file stored in the network file server. Each secondary server is programmed

17　　with a virus checker program executable for transferring file data from the file in the

18　　network file server to random access memory in the secondary server, and performing an

19　　anti-virus scan upon the file data in the random access memory of the secondary server.

20　　The network file server includes a cached disk array, and a plurality of data mover

21　　computers coupled to the data network and coupled to the cached disk array for

22　　responding to client requests for data access to storage in the cached disk array. At least

23　　one of the data movers is programmed to respond to a request from the client for access

1 to the file in the network file server by applying a filter upon a file extension of the file

2 upon opening or closing of the file to determine that an anti-virus scan of the file should

3 be performed, and initiating the anti-virus scan of the file by applying a load balancing

4 procedure for selecting one of the secondary servers for performing the anti-virus scan of

5 the file, and sending to the selected secondary server a request for the anti-virus scan

6 including a specification of the file.

7 In accordance with still another aspect, the invention provides a secondary server

8 adapted for coupling to a primary server in a data network for access to data in files in the

9 primary server. The secondary server is programmed with an operating system

10 supporting processes executing in a user mode and processes executing in a kernel mode.

11 The operating system includes an input/output manager executable in the kernel mode.

12 The secondary server is further programmed with a server for virus checking executable

13 in the user mode, a virus checking driver executable in the kernel mode, and a virus

14 checker program executable in the user mode. The server for virus checking is

15 executable for receiving from the network a request for an anti-virus scan upon a

16 specified file in the primary server, and for forwarding the request to the virus checker

17 initiator driver. The virus checker initiator driver is executable for responding to receipt

18 of the request from the server for virus checking by placing a file access call to the

19 input/output manager for access of the specified file. The input/output manager is

20 executable for responding to the file access call by reporting a file access event upon the

21 specified file to the virus checker program. The virus checker program is executable for

22 responding to the report of the file access event by transferring file data from the

23 specified file in the primary server to random access memory in the secondary server, and

1 performing an anti-virus scan upon the file data in the random access memory in the

2 secondary server.

3   In accordance with another aspect, the invention provides a data processing

4 system including at least one client, at least one network file server coupled to the client

5 by a data network for access of the client to at least one file in the network file server, and

6 a plurality of NT file servers coupled to the network file server by the data network for

7 data access of the NT file servers to the file in the network file server. The network file

8 server includes a cached disk array and a plurality of data mover computers coupled to

9 the data network and coupled to the cached disk array for responding to client requests

10 for data access to storage in the cached disk array. Each of the NT file servers is

11 programmed with a virus checker program that is executable by the NT file server to

12 perform an anti-virus scan upon file data in random access memory of the NT file server.

13 At least one data mover in the network file server is programmed for responding to a

14 request from the client for access to the file in the network file server by applying a filter

15 upon a file extension of the file upon opening or closing of the file to determine that an

16 anti-virus scan of the file should be performed, and initiating the anti-virus scan of the

17 file by selecting a next one of the NT file servers in round-robin fashion and sending to

18 the selected NT file server a request for the anti-virus scan including a specification of

19 the file. Each NT file server is programmed to respond to the request for the anti-virus

20 scan by invoking the virus checker program in the NT file server to perform an anti-virus

21 scan of the specified file by obtaining file data of the specified file from the network file

22 server and storing the file data of the specified file in the random access memory of the

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1 NT file server and performing the anti-virus scan upon the file data of the specified file in

2 the random access memory of the NT file server.

3   In accordance with yet another aspect, the invention provides a program storage

4 device containing a program executable by a network file server. The network file server

5 is adapted for coupling to at least one client for access of the client to at least one file in

6 the network file server. The network file server is also adapted for coupling to a plurality

7 of secondary servers for access of the secondary servers to the file stored in the network

8 file server. The secondary server is programmed with a virus checker program

9 executable for transferring file data from the file in the network file server to random

10 access memory in the secondary server, and performing an anti-virus scan upon the file

11 data in the random access memory of the secondary server. The program contained in the

12 program storage device is executable by the network file server for responding to a

13 request from the client for access to the file in the network file server by applying a filter

14 upon a file extension of the file upon opening or closing of the file to determine that an

15 anti-virus scan of the file should be performed, and initiating the anti-virus scan of the

16 file by applying a load balancing procedure for selecting one of the secondary servers for

17 performing the anti-virus scan of the file, and sending to the selected secondary server a

18 request for the anti-virus scan including a specification of the file.

19   In accordance with a final aspect, the invention provides a program storage device

20 containing a program executable by a secondary server. The secondary server is adapted

21 for coupling to a primary server in a data network for access to data in files in the primary

22 server. The secondary server is programmable with an operating system supporting

23 processes executing in a user mode and processes executing in a kernel mode. The

1 operating system includes an input/output manager executable in the kernel mode. The

2 secondary server is also programmable with a virus checker program for performing an

3 anti-virus scan upon file data in response to a file opening event being reported to the

4 input/output manager. The program contained in the program storage device includes a

5 server for virus checking executable in the user mode, and a virus checking driver

6 executable in the kernel mode. The server for virus checking is executable for receiving

7 from the network a request for the anti-virus scan upon a specified file in the primary

8 server, and for forwarding the request to the virus checker initiator driver. The virus

9 checker initiator driver is executable for responding to receipt of the request from the

10 server for virus checking by sending a file access call upon the specified file to the

11 input/output manager. The input/output manager responds to the file access call by

12 sending a report of a file access event upon the specified file to the virus checker program

13 to initiate an anti-virus scan upon file data of the specified file.

14   **BRIEF DESCRIPTION OF THE DRAWINGS**

15   Other objects and advantages of the invention will become apparent upon reading

16 the detailed description with reference to the drawings, in which:

17   FIG. 1 shows a block diagram of a data processing system incorporating the

18 present invention;

19   FIG. 2 is a block diagram of the cached disk array and one of the data movers in

20 the network file server of FIG. 1;

21   FIG. 3 is a block diagram of one of the NT file servers in the data processing

22 system of FIG. 1;

1   FIG. 4 is a table showing how two file attribute bits encode virus checking status

2   for a file in the network file server in FIG. 1;

3   FIG. 5 is a flowchart of a subroutine in an RPC client for virus checking in the

4   data mover of FIG. 2;

5   FIG. 6 is a flowchart of a subroutine of the RPC client for virus checking

6   responsive to an open file request from a client;

7   FIG. 7 is a flowchart of a subroutine in the RPC client for virus checking

8   responsive to a close file request from a client;

9   FIG. 8 is a flowchart of the processing of a request from the RPC client in FIG. 2

10   to the NT file server of FIG. 3 for virus checking of a specified file in the network file

11   server of FIG. 2;

12   FIG. 9 is a flowchart of a procedure in the RPC server for virus checking in the

13   NT file server of FIG. 3 for interfacing the RPC server with the conventional virus

14   checker program in the NT file server; and

15   FIG. 10 is a flowchart of a procedure for installing the network file server into the

16   data processing system of FIG. 1.

17   While the invention is susceptible to various modifications and alternative forms,

18   a specific embodiment thereof has been shown by way of example in the drawings and

19   will be described in detail. It should be understood, however, that it is not intended to

20   limit the form of the invention to the particular form shown, but on the contrary, the

21   intention is to cover all modifications, equivalents, and alternatives falling within the

22   scope of the invention as defined by the appended claims.

23

DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

With reference to FIG. 1, there is shown a data processing system incorporating the present invention. The data processing system includes a data network 21 interconnecting a number of clients and servers. The data network 21 may include any one or more of network connection technologies, such as Ethernet or Fibre Channel, and communication protocols, such as TCP/IP or UDP. The clients include work stations 22 and 23. The work stations, for example, are personal computers. The servers include conventional Windows NT/2000 file servers 24, 25, 26, and a very large capacity network file server 27. The network file server 27 functions as a primary server storing files in nonvolatile memory. The NT file servers 24, 25, 26 serve as secondary servers performing virus checking upon file data obtained from the network file server 27. The network file server 27 is further described in Vahalia et al., U.S. Patent 5,893,140 issued April 6, 1999, incorporated herein by reference. Such a very large capacity network file server 27 is manufactured and sold by EMC Corporation, 35 Parkwood Dr., Hopkinton, Mass. 01748.

The network file server 27 includes a cached disk array 28 and a number of data movers 29, 30 and 31. The network file server 27 is managed as a dedicated network appliance, integrated with popular network operating systems in a way, which, other than its superior performance, is transparent to the end user. The clustering of the data movers 29, 30, 31 as a front end to the cached disk array 28 provides parallelism and scalability. Each of the data movers 29, 30, 31 is a high-end commodity computer, providing the highest performance appropriate for a data mover at the lowest cost. Although the data mover computers 29, 30, and 31 may communicate with the other network devices using

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1   standard file access protocols such as the Network File System (NFS) or the Common

2   Internet File System (CIFS) protocols, the data mover computers do not necessarily

3   employ standard operating systems. For example, the network file server 27 is

4   programmed with a Unix-based file system that has been adapted for rapid file access and

5   streaming of data between the cached disk array 28 and the data network 21 by any one

6   of the data mover computers 29, 30, 31.

7   Each of the NT file servers 24, 25, 26 is programmed with a respective

8   conventional virus checker 27, 28, 29. The virus checkers are enterprise class anti-virus

9   engines, such as the NAI/McAfee's NetShield 4.5 for NT Server, Symantec Norton

10   AntiVirus 7.5 Corporate Edition for Windows NT, Trend Micro's ServerProtect 5.5 for

11   Windows NT Server. In each of the NT file servers 24, 25, 26, the virus checker 27, 28,

12   29 is invoked to scan a file in the file server in response to certain file access operations.

13   For example, when the file is opened for a user, the file is scanned prior to access by the

14   user, and when the file is closed, the file is scanned before permitting any other user to

15   access the file.

16   The network file server 27, however, is not programmed with a conventional virus

17   checker, because a conventional virus checker needs to run in the environment of a

18   conventional operating system. Network administrators, who are the purchasers of the

19   file servers, would like the network file server 27 to have a virus checking capability

20   similar to the virus checking provided in the conventional NT file servers 24, 25, 26.

21   Although a conventional virus checker could be modified to run in the environment of the

22   data mover operating system, or the data mover operating system could be modified to

23   support a conventional virus checker, the present invention provides a way for the

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1   network file server 27 to use the virus checkers 27, 28, 29 in the NT file servers to check

2   files in the network file server 27 in response to user access of the files in the network file

3   server. This avoids the difficulties of porting a conventional virus checker to the network

4   file server, and maintaining a conventional virus checker in the data mover environment

5   of the network file server. Moreover, in many cases, the high-capacity network file

6   server 27 is added to an existing data processing system that already includes one or more

7   NT file servers including conventional virus checkers. In such a system, all of the files in

8   the NT file servers 24, 25, 26 can be migrated to the high-capacity network file server 27

9   in order to facilitate storage management. The NT file servers 24, 25, 26 in effect

10 become obsolete for data storage, yet they can still serve a useful function by providing

11 virus checking services to the network file server.

12   In general, when a client 22, 23 stores or modifies a file in the network file server

13 27, the network file server determines when the file needs to be scanned. When anti-

14 virus scanning of a file has begun, other clients are blocked on any access to that file,

15 until the scan completes on the file. The network file server 27 selects a particular one of

16 the NT file servers 24, 25, 26 to perform the scan, in order to balance loading upon the

17 NT file servers for anti-virus scanning processes. The virus checker in the selected NT

18 file server performs a read-only access of the file to transfer file data from the network

19 file server to random access memory in the selected NT file server in order to perform the

20 anti-virus scan in the NT file server.

21   Typically the anti-virus scan is a search for certain patterns of known viruses.

22 Another method, applicable to read-only files, is to maintain a separate registry of

23 hashings computed from the file contents when the files were known to be devoid of any

1   viruses. In this alternative method, the anti-virus scan computes a hashing of the file

2   content, and compares the hashing to the hashing in the registry. If the computed hashing

3   does not match the hashing in the registry, the file is indicated as infected. In any case,

4   the result of the scan, indicating whether the file is found to be infected or not, is returned

5   from the virus checker in the NT file server to the network file server 27. If the file is

6   indicated as infected, then the network file server blocks any further access of the client

7   to the file in the network file server.

8   Referring to FIG. 2, there is shown a block diagram of software structure that is

9   replicated in each data mover. The software structure includes modules 41 and 42 for the

10 Network File System (NFS) file access protocol (FAP) and the Common Internet File

11 System (CIFS) file access protocol, a Virtual File System (VFS) 43, and a Unix-based

12 file system (UxFS). The Virtual File System (VFS), which is an industry-standard back-

13 end file system switch, interfaces with the UxFS physical file system 44. VFS translates

14 NFS Common File System requests. (The NFS Common File System Requests in

15 themselves are translations of NFS requests to the intended physical file storage devices.)

16 UxFS accesses a file system buffer cache 45 during data transfers between the data

17 network 21 and disk storage in the cached disk array 28.

18   In accordance with an aspect of the present invention, a Remote Procedure Call

19 (RPC) client for virus checking 46 is integrated with the UxFS module 44. For example,

20 the UxFS module 44, including the RPC client for virus checking 46, is read from a

21 machine readable program storage device such as a floppy disk 47, and loaded into data

22 storage of the data mover 29. The RPC client for virus checking 46 is invoked directly or

23 indirectly to initiate an anti-virus scan of a specified file. For example, as further

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1   described below with reference to FIGs. 6 and 7, the RPC client for virus checking 46 is

2   invoked indirectly when a client attempts to open a file that has not been checked for

3   viruses, and when a client closes a file after a write operation that creates or modifies the

4   file. In this case, the RPC client for virus checking 46 intercepts calls originally intended

5   for the open and close file routines 48 in the UxFS 44.

6   Upon closing of a file after a write operation, the new file data is written down

7   from the file system cache 45 to the UxFS files 49 in the cached disk array 28. The

8   cached disk array 28 also stores UxFS file attributes 50. For virus checking, the file

9   attributes indicate that the files to be checked have shared access with the NT servers, so

10 that the virus checkers in the NT servers may share access to the files. The file attributes

11 also include virus check status. The RPC client for virus checking maintains the virus

12 check status as further described below with reference to FIGs. 4 and 5.

13   FIG. 3 shows components in the NT file server 24. The Windows NT/2000

14 operating system includes an input/output (IO) manager 51, including a Multiple

15 Universal Naming Convention Provider (MUP) 52. The MUP 52 resolves the pathnames

16 of objects such as clients, servers, and files in the data processing system of FIG. 1. As

17 described with respect to FIGs. 1 and 2, when the RPC client for virus checking 46 in the

18 network file server 27 determines that an anti-virus scan of a file is needed, the RPC

19 client for virus checking sends a request to the conventional virus checker program 27 of

20 the NT file server. However, the conventional virus checker program 27 typically is not

21 programmed to receive a request from a source external to the NT file server 24. Even if

22 the conventional virus checker program 27 were programmed to receive such an external

23 request, it may be undesirable for the network file server to directly invoke the

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1   conventional virus checker program because the conventional virus checker program

2   might be upgraded in such a way that the upgraded virus checker program would fail to

3   recognize the external request.

4   What is desired is a way of stimulating the operating system of the NT file server

5   to cause the conventional virus checker program to check an external file. Therefore, if

6   the conventional virus checker program were upgraded in a fashion compatible with the

7   Windows NT/2000 operating system, the upgraded virus checker program would

8   continue to be invoked by the RPC client for virus checking in the network file server.

9   To accomplish this task, the NT file server is programmed with a RPC server for virus

10   checking 53 that executes in user mode, and a virus checker initiator driver 54 that

11   executes in kernel mode. The RPC server for virus checking 53 and the virus checker

12   initiator driver 54 are loaded into the NT file server 24 from a programmed storage

13   device such as the floppy disk 55. The RPC server for virus checking 53 responds to an

14   Open Network Computing (ONC) Remote Procedure Call (RPC) from the RPC client for

15   virus checking in the network file server. In particular, the I/O manager 51 receives the

16   ONC/RPC requests from the data network 21, and the MUP 52 directs the request to the

17   RPC server for virus checking 53. The ONC/RPC request includes a path specification

18   for the file to be checked. The path specification includes the file name in accordance

19   with the Universal Naming Convention (UNC). Such a path specification looks like

20   *\\servername\sharename\path\file*. The RPC server for virus checking sends an

21   input/output control command (IOCTL) and the path specification to the virus checker

22   initiator driver 54. The virus checker initiator driver 54 responds by sending a file

23   opening call for the file in the form of ZwCreateFile to the I/O manager 51. The file

1   opening call includes the path specification for the file. The conventional virus checker

2   program 27 is registered with the I/O manager 51 to receive a report of such a file

3   opening event, and to return a condition code indicating success or failure of an anti-virus

4   scan upon the specified file. The I/O manager 51 responds to the file opening call by

5   sending a report of the file opening event to the conventional virus checker program 27.

6   In particular, the I/O manager 51 sends an IRP_MJ_CREATE command and the ONC

7   path specification to a conventional virus checker filter driver 57, which forwards the

8   report of the file opening event to the conventional virus checker program 27. In

9   response to the report of the file opening event, the conventional virus checker program

10   27 performs an anti-virus scan upon the specified file in the network file server.

11   The conventional virus checker program performs the anti-virus scan by

12   performing a read-only access upon the file to transfer file data to random access memory

13   (RAM) 56 in the NT file server, and to scan the file data in the RAM of the NT file

14   server. The ONC/RPC file checking request sent to the NT file server includes the name

15   of the file but not the content of the file. The conventional virus checker program

16   running on the NT file server has the responsibility of employing its heuristics to

17   determine the appropriate parts of the file to bring across to the NT file server for

18   scanning purposes. This renders the scans of most file types highly efficient. (The worst

19   case scenario is a scan of a compressed or zip type file.) The conventional virus checker

20   program 27 then returns the condition code to the I/O manager 51. The I/O manager 51,

21   the virus checker initiator driver 54, and the RPC server for virus checking 53 in

22   sequence return the condition code to the RPC client for virus checking in the network

23   file server.

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It should be apparent that each file in the network file server (27 in FIGS. 1 and 2) has a particular status with respect to virus checking. For example, virus checking may never have been performed upon the file, checking could have been begun for the file, the file may have been checked and found to be ok as far as the virus checker can determine, or the file could have been checked and found to be infected with a virus. The present virus checking status of a file could be indicated by two file attribute bits, as shown in FIG. 4. These attribute bits, for example, are stored in the UxFS file attributes (50 in FIG. 2) in the cached disk array (28 in FIG. 2). By storing the file attribute bits in the cached disk array, they are preserved for diagnostic and recovery purposes in the event of a system crash. Moreover, each of the data movers in the network file server may have access to these file attribute bits so that each of the data movers could control file access and virus checking for any one of the UxFS files.

An alternative to using file attributes bits for storing virus check status is to maintain respective lists or caches of file names for the most infrequent file status. For example, if files are virus checked before they are ever stored on the network file server, then under normal conditions, only a small number of files should ever be in the unchecked, scanning, or infected states. In this case it is desirable to keep, in battery-backed random access memory, at least the cache of the file names of files that are in the process of being scanned. If a loss of line power occurs, the content of the battery-backed random access memory is written to a disk drive to preserve the data before any loss of battery power.

With reference to FIG. 5, there is shown a flow chart of an anti-virus scan procedure performed by the RPC client for virus checking (46 in FIG. 2). In the first step

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1   61 of FIG. 5, the RPC client marks the file status as "scanning." Then in step 62, the

2   RPC client selects a next one of the NT file servers in round-robin fashion in order to

3   balance loading of file scan requests upon the NT file servers. In other words, for the

4   case of a number (N) of NT file servers, the data mover maintains an index ranging from

5   0 to N-1 indicating the last one of the NT file servers to receive an anti-virus scan request

6   from the data mover. The RPC client increments this index, and sets it to 0 if it is greater

7   or equal to N. This value is used as the index for selecting the next NT file server in

8   round-robin fashion.

9   In a preferred implementation, the RPC client for virus checking is multi-threaded

10   and supports configurable parameters that set and affect how the RPC client behaves.

11   For example, multiple file checking requests can be queued for transmission to the NT

12   file servers. In this case, if a file checking request has already been assigned to the next

13   NT file server, then the index will be advanced to the next NT file server that does not

14   have an outstanding file checking request assigned to it by the data mover. If all of the

15   NT file servers have outstanding file checking requests, then up to a predetermined

16   number of outstanding requests from the data mover will be assigned and transmitted to

17   the NT file servers. For example, in step 62 the name of the file to be checked is placed

18   on a queue that is serviced by a pool of threads. Each thread dispatches a request to an

19   assigned NT file server and waits for a reply. After the reply is received and process, the

20   thread is again available for servicing the queue. The number of threads in the pool is

21   configurable and has a default value of twenty. The queue of file names indicates the

22   files having the checking status.

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1   In step 63, the RPC client (and more particularly, in the preferred implementation,

2   a thread from the pool) sends an ONC/RPC to the RPC server for virus checking in the

3   selected NT file server. In step 64, the RPC client inspects the reply from the RPC

4   server. If the reply indicates that the scan was not successful, then the file attribute bits

5   for scanning are set to mark the file as infected in step 65, and the RPC client returns and

6   error code to the calling routine. Otherwise, if the scan was successful, execution

7   continues from step 64 to step 66 to mark the file as ok, and execution returns to the

8   calling routine.

9   With reference to FIG. 6, there is shown a flowchart of a subroutine of the RPC

10   client for virus checking responsive to an open file request from a network client. This

11   subroutine is called in the modified UxFS in lieu of the UxFS subroutine originally called

12   in order to open a file for a network client. In a first step 70, a filter is applied to the file

13   extension of the file to be opened. The filter may also ensure that files larger than a

14   certain configurable limit are not checked for viruses. Typically the filter is a list of file

15   extensions for all executable file types, so that the file extension for any executable file

16   will meet the criteria of the filter. For example, the filter is configurable with a command

17   such as:

18   masks=*.EXE:*.COM:*.XL?,

19   which instructs the RPC client to initiate scanning of only files ending in .EXE, .COM,

20   .XLT, .XLS etc. If the file extension does not meet the criteria of the filter, then the file

21   will not be checked for viruses, and execution branches to step 71 to open the file for

22   requesting process, and the routine is finished.

1   If the file extension meets the criteria of the filter, then execution continues from

2   step 70 to step 72. In step 72, the RPC client inspects the file attributes to determine

3   whether the file is marked as ok. If so, then execution branches to step 71. If in step 72

4   the file is not marked as ok, execution continues to step 73. In step 73, the RPC client

5   checks whether the process requesting the opening of the file is a privileged process. For

6   example, the conventional virus checker program in the NT file server and the RPC

7   server for virus checking on the NT file server are such privileged processes. These

8   privileged processes have full access to the file being scanned to be able to rename,

9   rename extension, quarantine/move, and delete, repair, or modify the file. At the same

10   time, accesses of other clients to the file are blocked. For a privileged process, execution

11   branches from step 73 to step 71 to open the file for the requesting process, and the

12   routine is finished. In this fashion, the opening of a file in the network file server by the

13   virus checker in the NT file server does not cause an infinite indirect recursive loop.

14   If in step 73 the process requesting the opening of the file is not a privileged

15   process, execution continues to step 74. In step 74, execution branches to step 75 if the

16   file is already being checked for viruses. This prevents multiple concurrent invocations

17   of virus checking upon the same file. In step 75 a timer is set with a configurable value

18   indicative of a maximum amount of time that should be required for anti-virus scanning

19   of the file. Execution continues from step 75 to step 76 to suspend and then resume

20   execution of the subroutine, in order to spend some time waiting for the checking of the

21   file to complete. If in step 77 the checking of the file is still ongoing, execution continues

22   to step 78. In step 78, the timer is checked to determine whether an unreasonable amount

23   of time has elapsed. If so, then the subroutine may return an error code to the requesting

1   process, indicating that the opening of the file has been blocked by the virus checking. If

2   the client is requesting a read access of the file, the RPC client could report the error to

3   the system administrator, and then allow access to the file by branching to step 71. This

4   is a design choice as to whether the cost of blocking a client's access to the file is greater

5   than the cost of accessing a potentially infected file.

6   In step 78, if an unreasonable amount of time has not elapsed, execution loops

7   back from step 78 to step 76 to continue checking of the file. If in step 77 the checking

8   of the file is finished, then execution branches to step 79. In step 79, the file attributes

9   are inspected to determine whether the checking of the file has succeeded. If the file is

10   marked as ok, then execution branches to step 72 to open the file for the requesting

11   process. Otherwise, execution returns with an error code indicating that the file has not

12   been opened because the file is infected.

13   If in step 74 the file was not being checked, then execution continues to step 80.

14   In step 80, the file attributes are inspected to determine whether the file is infected. If so,

15   then execution returns with an error code indicating that the file will not be opened

16   because it is infected. Otherwise, execution continues from step 80 to step 81. In step

17   81, the subroutine of FIG. 6 calls the RPC client subroutine of FIG. 5 for anti-virus

18   scanning of the file. Then execution continues to step 82. If the scan was successful,

19   then execution branches to step 72 to open the file for the requesting process, and the

20   routine is done. Otherwise, if the scan was not successful, then the subroutine of FIG. 6

21   is finished, and it returns an error code indicating that the file will not be opened because

22   the file is infected.

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1   FIG. 7 shows the procedure followed by the RPC client when a client process

2   requests a file to be closed. In a first step 90, the file extension filter is applied to the file

3   extension. If the file extension does not meet the criteria of the filter, then it will not be

4   subjected to an anti-virus scan, and execution branches to step 91. In step 91, the RPC

5   client closes the file for the calling process, and the routine is finished.

6   If the file extension meets the criteria of the file extension filter, then execution

7   continues from step 90 to step 92. In step 92, execution branches to step 91 if the process

8   closing the file has not written to or modified the file. Otherwise, execution continues

9   from step 92 to step 93. In step 93, if the process requesting the closing of the file is a

10 privileged process, then execution branches to step 91 to close the file. For example, an

11 invocation of the virus checker in the NT file server is such a privileged process.

12 Otherwise, execution continues from step 93 to step 94. In step 94, the file is marked by

13 setting the file attributes to indicate that the file is undergoing virus checking. Execution

14 continues from step 94 to step 95. In step 95 the file is closed for the calling process.

15 The file is marked for scanning in step 94 prior to closing of the file in step 95 so that in

16 the event of a crash just after the closing of the file, the interrupted scanning can be

17 completed during a recovery operation. In step 96 the routine calls the RPC client

18 subroutine for an anti-virus scan of the file, as shown in FIG. 5. In this case, the

19 preferred entry point is step 62 in FIG. 5, because step 61 has already been performed in

20 step 94 of FIG. 7. Upon return from the subroutine in FIG. 5, the routine of FIG. 7 is

21 finished.

22   The RPC client for virus checking could check a file in response to additional

23 events, such as when a file is renamed, and when a link to a file is created. Checking in

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1   response to these additional events is advantageous when the filtering of step 70 in FIG. 6

2   and 90 in FIG. 7 are based on file extension, because the renaming or creation of the link

3   might otherwise defeat the intent of the filter.

4   FIG. 8 shows a flowchart of the procedure performed by the NT file server when

5   processing and ONC/RPC from the RPC client for virus checking. This procedure was

6   introduced above with reference to FIG. 3. In the first step 101 the I/O manager routes

7   the ONC/RPC to the RPC server for virus checking, which executes in user mode of the

8   Windows NT/2000 operating system. Then in step 102, the RPC server sends the IOCTL

9   and file path specification to the virus checker initiator driver executing in the kernel

10   mode. In step 103 the virus checker initiator driver sends a file opening call including the

11   file path specification to the I/O manager. In step 104 the I/O manager interprets the file

12   opening call as a file opening event and reports the event to the conventional virus

13   checker program, which is executing in user mode. In step 105 the conventional virus

14   checker program reads file data from the file in the network file server into random

15   access memory of the NT file server, scans the file data in the random access memory to

16   check for viruses, and returns a response, such as a condition code, to the I/O manager.

17   Then in step 106 the I/O manager returns the response of the conventional virus checker

18   program to the virus checker initiator driver. In step 107 the virus checker initiator driver

19   returns the response to the RPC server for virus checking. Finally, in step 108, the RPC

20   server for virus checking returns the response to the RPC client for virus checking, and

21   the routine is finished.

22   In a preferred implementation, the RPC server for virus checking is multi-

23   threaded and supports NT registry configurable parameters that set and affect how the

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1   server behaves in order to support and interface to many different kinds of conventional

2   virus checker programs. For example, a configurable interface selection parameter is

3   interpreted as shown in FIG. 9. The interface selection parameter specifies either

4   indirect, command line interface (CLI), application program interface (API), or

5   communications interface (COM). For the interface parameter set to "indirect," as tested

6   in step 111, the RPC server uses the virus checker initiator driver for kernel-mode

7   stimulation of the conventional virus checker program, as shown in step 112. This is the

8   preferred interface method, because it can work with a wide variety of conventional virus

9   checker programs and it is the most insensitive to any downward compatible upgrading

10   of the virus checker program. For example, the same virus checking driver for the

11   Windows NT/2000 operating system can support the NAI/McAfee's NetShield 4.5 for

12   NT Server, Symantec Norton AntiVirus 7.5 Corporate Edition for Windows NT, and

13   Trend Micro's ServerProtect 5.5 for Windows NT server. For the interface parameter set

14   to "CLI," as tested in step 113, the RPC server sends a command line request to the

15   conventional virus checker program to initiate an anti-virus scan, as shown in step 114.

16   The CLI method can be used to interface with the McAfee's VirusScan program. For the

17   interface parameter set to "API," as tested in step 115, the RPC server sends an API call

18   to the conventional virus checker program to initiate an anti-virus scan, as shown in step

19   116. The API method can be used to interface with Trend Micro's VSAPI program, or

20   Symantec's CarrierScan program. Finally, with the interface parameter set to "COM," as

21   tested in step 117, the RPC server sends a COM request to the conventional virus checker

22   program to initiate an anti-virus scan, as shown in step 118.

1   The protocol between the virus checker client in the network file server and the

2   virus checker server in the NT file server could also be configurable for a protocol other

3   than ONC/RPC. Moreover, the commands sent from the RPC client for virus checking to

4   the RPC server for virus checking could include a "checking type" parameter to support

5   file checking functionality other that virus checking, such as content checking of a file.

6   FIG. 10 shows a flow chart of a procedure for installing the network file server

7   (27 in FIG. 1) into the data processing system of FIG. 1. In a first step 121, each NT file

8   server is loaded with the RPC server for virus checking and with the virus checker

9   initiator driver. Then in step 122 each data mover of the network file server is loaded

10   with the RPC client for virus checking. In step 123 files are migrated to the network file

11   server, for example, from the NT file servers. In step 124 the files in the network file

12   server are marked as shared with the NT file servers, and are initially marked as "not

13   checked". Then in step 125, the data movers of the network file server begin a

14   background task of virus checking of the files marked as unchecked, while giving

15   network clients priority access.

16   In a preferred implementation, the network file server is set up by the following

17   commands. In a boot.cfg file on the data mover, the only command is "check start".

18   This command starts the RPC client for virus checking on the data movers.

19   In a /.etc/viruschecker.conf file on the data mover, the following configuration

20   parameters are stored: 'masks=<list of filename extensions>' sets the list of filemasks

21   that need to be checked; 'addr=<list of IP addresses>' sets the IP addresses of the NT

22   servers including the virus checker programs that are to be used with the data mover;

23   'CIFSserver=<name of the RPC server>' sets the name of the RPC server for virus

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1   checking in the data mover; and 'maxsize=xxxx (32 bits)'sets the maximum file size that

2   will be checked.

3   A specific example is the following:

4   masks=*.EXE:*.COM:*.DOC:*.DOT:*.XL?:*.MD?:*.VXD:*.386:*.SYS:*.BIN

5   masks=*.RTF:*.OBD:*.DLL:*.SCR:*.OBT:*.PP?:*.POT:*.OLE:*.SHS:*.MPP

6   masks=*.MPT:*.XTP:*.XLB:*.CMD:*.OVL:*.DEV

7   masks=*.ZIP:*.TAR:*.ARJ:*.ARC:*.Z

8   addr=168.159.173.239

9   In the preferred embodiment, the data mover is also responsive to a number of

10   check commands. These check commands include:

11   1. 'check start' - starts the RPC client for virus checking on the data mover and

12   connects to the listed RPC server for virus checking;

13   2. 'check stop' - stops the RPC client for virus checking on the data mover;

14   3. 'check' - displays the configuration of the RPC client for virus checking;

15   4. 'check audit' - displays the status of the RPC client for virus checking; and

16   5. 'param check Traces=n' – displays a trace output of virus checking on the

17   operator's console ('TRACES=4' provides a trace of invocations of the virus checker

18   program from the RPC servers, 'TRACES=2' provides a trace of the RPC messages

19   between the RPC client and the RPC server, and 'TRACES=1' provides a trace of calls in

20   the data mover to the RPC client).

21   Often it will be found that the virus checker program is incapable of detecting a

22   new virus. In this case, the supplier of the anti-virus program will distribute an updated

23   pattern file that may be used by the conventional virus checker program to detect the new

1   virus. In such a case, all of the files in the network file server can be marked as

2   unchecked, and then step 115 can be repeated in order to check all of the files using the

3   updated pattern file.

4   Following the specification and preceding the claims is a listing of source code

5   for the RPC driver for virus checking.

6   In view of the above, there has been described a method of using a conventional

7   virus checker program in one network file server to check for viruses when files in

8   another network file server are accessed by network clients. In the preferred

9   implementation, when a network client accesses a file in a network file server using a

10   specialized operating system, the network file server invokes a conventional virus

11   checker program in an NT file server to transfer pertinent file data from the network file

12   server to random access memory in the NT file server, and to perform an anti-virus scan

13   of the file data in the random access memory of the NT file server. The conventional

14   virus checker program then returns a condition code to the network file server to indicate

15   whether or not the file was found to be infected, although the conventional virus checker

16   program also implements its conventional action policy when the file is found to be

17   infected. In other words, the method retains the normal functionality provided by the

18   conventional virus checker program. Therefore, users can still interact with the

19   conventional virus checker program in the usual fashion, for example through a graphical

20   interface provided by the virus checker program for selecting the file types that should be

21   checked, and the actions that should be taken when a file of a specified type is found to

22   be infected. Because the conventional virus checker program is not loaded or executed in

23   the network file server, there is no need for porting the virus checker program to the

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specialized operating system of the network file server, nor is there any need for

maintenance in the network file server when the conventional virus checker program is

updated with a new virus pattern file or upgraded. Moreover, in the preferred

implementation, there is an indirect interface in the NT file server between the commands

from the network file server for initiating a virus scan and the conventional virus checker

program. This indirect interface operates in the kernel mode to report a file opening

event to the I/O manager, which notifies the conventional virus checker program. In this

fashion, the indirect interface supports a wide variety of conventional virus checker

programs, and ensures that the interface will continue to operate properly with any

downward compatible upgrade of the conventional virus checker program.

EXAMPLE OF RPC DRIVER FOR VIRUS CHECKING

```
/* Module Name: fscvir.ini /*

\registry\machine\system\currentcontrolset\services\FSCVIR

     Type = REG_DWORD 0x00000001

     Start = REG_DWORD 0x00000003

     Group = Extended base

     ErrorControl = REG_DWORD 0x00000001

/* Module Name: fscvir.h; Environment: kernel & User mode

*/

#define     FSCVIR_MAXPATH 1024     // max number of

unicode characters in UNC path

#define     FSCVIR_DEFAULT_FILE_NAME

L"\\??\\m:\\test\\fscvir.tst"
```

```
#define      FSCVIR_UNC_DEFAULT_FILE_NAME

L"\\Device\\mup\\perf2\\server2fs1\\test\\fscvir.tst"

/* Define the various device type values.  Note that values

used by Microsoft Corporation are in the range 0- 32767,

and 32768-65535 are reserved for use by customers. */

#define FILE_DEVICE_FSCVIR  0x00008000

/*  Macro definition for defining IOCTL and FSCTL function

control codes.  Note that function codes 0-2047 are

reserved for Microsoft Corporation, and 2048-4095 are

reserved for customers. */

#define FSCVIR_IOCTL_INDEX  0x800

// Define our own private IOCTL

#define IOCTL_FSCVIR_CHECK_UNCPATH

CTL_CODE(FILE_DEVICE_FSCVIR , \

FSCVIR_IOCTL_INDEX,  \

METHOD_BUFFERED,       \

FILE_ANY_ACCESS)

#define IOCTL_FSCVIR_UNMAP_USER_PHYSICAL_MEMORY

CTL_CODE(FILE_DEVICE_FSCVIR, \

FSCVIR_IOCTL_INDEX+1,\

METHOD_BUFFERED,      \

FILE_ANY_ACCESS)

// Our user mode app will pass an initialized structure

// like this down to the kernel mode driver
```

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```
typedef struct

{

    WCHAR    UNCPath[FSCVIR_MAXPATH]; // UNC path to file

} FSCVIR_INFO, *PFSCVIR_INFO;

/* Module Name: fscvir.c  Abstract:  A driver which will

issue file system IRP's [IRP_MJ_CREATE] targeted at a file

supplied by a user-mode .exe communicating with a file

server. This IRP will stimulate a resident anti-virus

engine to check the UNC path to file for contamination.

Environment:  kernel mode only */

#include "ntddk.h"

#include "fscvir.h"

#include "stdarg.h"

#define DBG      1

NTSTATUS

FscVirDispatch(

    IN PDEVICE_OBJECT DeviceObject,

    IN PIRP Irp

    );

VOID

FscVirUnload(

    IN PDRIVER_OBJECT DriverObject

    );

NTSTATUS
```

```
FscVirCheckFile(

    IN PDEVICE_OBJECT DeviceObject,

    IN OUT PVOID        ioBuffer,

    IN ULONG            inputBufferLength,

    IN ULONG            outputBufferLength

    );

#if DBG

#define FscVirKdPrint(arg) DbgPrint arg

#else

#define FscVirKdPrint(arg)

#endif

NTSTATUS

DriverEntry(

    IN PDRIVER_OBJECT  DriverObject,

    IN PUNICODE_STRING RegistryPath

    )

/* Routine Description:  Installable driver initialization

entry point.  This entry point is called directly by the

I/O system. Arguments: DriverObject - pointer to the driver

object; RegistryPath - pointer to a unicode string

representing the path to driver-specific key in the

registry.  Return Value: STATUS_SUCCESS if successful,

STATUS_UNSUCCESSFUL otherwise  */

{
```

```
1        PDEVICE_OBJECT deviceObject = NULL;

2        NTSTATUS        ntStatus;

3        WCHAR           deviceNameBuffer[] =

4    L"\\Device\\FSCVIR";

5        UNICODE_STRING deviceNameUnicodeString;

6        WCHAR           deviceLinkBuffer[] =

7    L"\\DosDevices\\FSCVIR";

8        UNICODE_STRING deviceLinkUnicodeString;

9        FscVirKdPrint (("FSCVIR.SYS: entering DriverEntry\n"));

10       // Create an EXCLUSIVE device object (only 1 thread at

11       // a time can make requests to this device)

12       RtlInitUnicodeString (&deviceNameUnicodeString,

13                             deviceNameBuffer);

14       FscVirKdPrint (("FSCVIR.SYS: entering DriverEntry\n"));

15       ntStatus = IoCreateDevice (DriverObject,

16                                  0,

17                                  &deviceNameUnicodeString,

18                                  FILE_DEVICE_FSCVIR,

19                                  0,

20                                  TRUE,

21                                  &deviceObject

22                                  );

23       if (NT_SUCCESS(ntStatus))

24           {
```

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```
 1        //

 2        // Create dispatch points for device control, create,

 3   close.

 4        //

 5            DriverObject->MajorFunction[IRP_MJ_CREATE]

 6   =

 7            DriverObject->MajorFunction[IRP_MJ_CLOSE]

 8   =

 9            DriverObject->MajorFunction[IRP_MJ_DEVICE_CONTROL]

10   = FscVirDispatch;

11            DriverObject->DriverUnload

12   = FscVirUnload;

13        //    Create a symbolic link, e.g. a name that a Win32 app

14        // can specify to open the device

15            RtlInitUnicodeString(&deviceLinkUnicodeString,

16                                  deviceLinkBuffer);

17            ntStatus = IoCreateSymbolicLink

18   (&deviceLinkUnicodeString,

19   &deviceNameUnicodeString);

20            if (!NT_SUCCESS(ntStatus))

21            {

22        // Symbolic link creation failed- note this & then delete

23        // the device object (it's useless if a Win32 app can't

24        // get at it).
```

```
            FscVirKdPrint (("FSCVIR.SYS:

IoCreateSymbolicLink failed\n"));

            IoDeleteDevice (deviceObject);
        }
    }
    else
    {
        FscVirKdPrint (("FSCVIR.SYS: IoCreateDevice

failed\n"));
    }
    return ntStatus;
}
NTSTATUS
FscVirDispatch(
    IN PDEVICE_OBJECT DeviceObject,
    IN PIRP Irp
    )
/* Routine Description:  Process the IRPs sent to this
device. Arguments:  DeviceObject - pointer to a device
object; Irp - pointer to an I/O Request Packet  */
{
    PIO_STACK_LOCATION irpStack;
    PVOID              ioBuffer;
    ULONG             inputBufferLength;
```

```
1      ULONG                outputBufferLength;

2      ULONG                ioControlCode;

3      NTSTATUS             ntStatus;

4    // Init to default settings- we only expect 1 type of

5    // IOCTL to roll through here, all others an error.

6      Irp->IoStatus.Status      = STATUS_SUCCESS;

7      Irp->IoStatus.Information = 0;

8  // Get a pointer to the current location in the Irp. This

9  // is where the function codes and parameters are located.

10     irpStack = IoGetCurrentIrpStackLocation(Irp);

11 // Get the pointer to the input/output buffer and it's

12 // length

13     ioBuffer            = Irp->AssociatedIrp.SystemBuffer;

14     inputBufferLength   = irpStack-

15 >Parameters.DeviceIoControl.InputBufferLength;

16     outputBufferLength = irpStack-

17 >Parameters.DeviceIoControl.OutputBufferLength;

18     switch (irpStack->MajorFunction)

19     {

20     case IRP_MJ_CREATE:

21         FscVirKdPrint (("FSCVIR.SYS: IRP_MJ_CREATE\n"));

22         break;

23     case IRP_MJ_CLOSE:

24         FscVirKdPrint (("FSCVIR.SYS: IRP_MJ_CLOSE\n"));
```

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```
1              break;

2          case IRP_MJ_DEVICE_CONTROL:

3              ioControlCode = irpStack-

4  >Parameters.DeviceIoControl.IoControlCode;

5              switch (ioControlCode)

6              {

7              case IOCTL_FSCVIR_CHECK_UNCPATH:

8              FscVirKdPrint (("FSCVIR.SYS:

9  IOCTL_FSCVIR_CHECK_FILE\n"));

10                 Irp->IoStatus.Status = FscVirCheckFile

11                                       (DeviceObject,

12                                        ioBuffer,

13                                        inputBufferLength,

14                                        outputBufferLength

15                                                      );

16             if (NT_SUCCESS(Irp->IoStatus.Status))

17             {

18  // Success! Set the following to sizeof(PVOID) to

19  //     indicate we're passing valid data back.

20                 Irp->IoStatus.Information = sizeof(PVOID);

21                 FscVirKdPrint (("FSCVIR.SYS: file

22  successfully checked\n"));

23             }

24             else
```

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```
            {
                Irp->IoStatus.Status =
    STATUS_INVALID_PARAMETER;
    FscVirKdPrint (("FSCVIR.SYS: file check failed\n"));
            }
        break;
      default:
            FscVirKdPrint (("FSCVIR.SYS: unknown
    IRP_MJ_DEVICE_CONTROL\n"));
            Irp->IoStatus.Status =
STATUS_INVALID_PARAMETER;
            break;
        }
        break;
    }
    ntStatus = Irp->IoStatus.Status;
    IoCompleteRequest(Irp,
                        IO_NO_INCREMENT);
    // We never have pending operation so always
    // return the status code.
    return ntStatus;
}
VOID
FscVirUnload(
```

```
    IN PDRIVER_OBJECT DriverObject

        )

    /* Routine Description: Just delete the associated device &

    return. Arguments: DriverObject - pointer to a driver

    object */

    {

        WCHAR                      deviceLinkBuffer[]  =

    L"\\DosDevices\\FSCVIR";

        UNICODE_STRING         deviceLinkUnicodeString;

      // Free any resources

      // Delete the symbolic link

        RtlInitUnicodeString (&deviceLinkUnicodeString,

                                    deviceLinkBuffer

                                    );

        IoDeleteSymbolicLink (&deviceLinkUnicodeString);

    // Delete the device object

        FscVirKdPrint (("FSCVIR.SYS: unloading\n"));

        IoDeleteDevice (DriverObject->DeviceObject);

    }

    NTSTATUS

    FscVirCheckFile(

        IN PDEVICE_OBJECT DeviceObject,

        IN OUT PVOID      IoBuffer,

        IN ULONG          InputBufferLength,
```

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```
 1      IN ULONG            OutputBufferLength

 2          )

 3      /* Arguments: DeviceObject -; pointer to a device object;

 4      IoBuffer - pointer to the I/O buffer; InputBufferLength  -

 5      input buffer length; OutputBufferLength - output buffer

 6      length;

 7      Return Value:  STATUS_SUCCESS if successful, otherwise

 8      STATUS_UNSUCCESSFUL, STATUS_INSUFFICIENT_RESOURCES, (other

 9      STATUS_* as returned by kernel APIs)   */

10      {

11          PFSCVIR_INFO ppmi = (PFSCVIR_INFO) IoBuffer;

12          NTSTATUS     ntStatus;

13          IO_STATUS_BLOCK     IoStatus;

14          WCHAR         buffer[1024];

15          UNICODE_STRING     fileName;

16          OBJECT_ATTRIBUTES   ObjectAttributes;

17          HANDLE              NtFileHandle;

18          if ( ( InputBufferLength  < sizeof (FSCVIR_INFO) ) ||

19              ( OutputBufferLength < sizeof (PVOID) ) )

20          {

21          FscVirKdPrint (("FSCVIR.SYS: Insufficient input or

22      output buffer\n"));

23          ntStatus = STATUS_INSUFFICIENT_RESOURCES;

24          return ntStatus;
```

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```
1          }

2      //wcscpy(buffer,ppmi->UNCPath);

3      //FscVirKdPrint (("FSCVIR.SYS: system buffer is [%x]

4      //length[%ld]\n", &buffer, InputBufferLength));

5      // RtlInitUnicodeString( &fileName,

6   FSCVIR_DEFAULT_FILE_NAME );

7         RtlInitUnicodeString( &fileName,

8   FSCVIR_UNC_DEFAULT_FILE_NAME );

9         InitializeObjectAttributes( &ObjectAttributes,

10                                    &fileName,

11                                    OBJ_CASE_INSENSITIVE,

12                                    NULL,

13                                    NULL);

14     FscVirKdPrint (("FSCVIR.SYS: attempting to open

15   [%wZ][%wZ]\n", &fileName, ObjectAttributes.ObjectName));

16        ntStatus = ZwCreateFile(    &NtFileHandle,

17                                    GENERIC_READ |

18   GENERIC_WRITE,

19                                    &ObjectAttributes,

20                                    &IoStatus,

21                                    NULL,

22                                    FILE_ATTRIBUTE_NORMAL,

23                                    FILE_SHARE_READ,

24                                    FILE_OPEN,
```

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```
FILE_SYNCHRONOUS_IO_NONALERT |

                              FILE_NON_DIRECTORY_FILE |

                              FILE_SEQUENTIAL_ONLY,

                              NULL,

                              0 );

    FscVirKdPrint (("FSCVIR.SYS: ZwCreateFile

returns[%x]\n", ntStatus));

    ZwClose(NtFileHandle);

    return ntStatus;

      }
```